ORIGINAL ARTICLE

Synergisms between climate change mitigation and adaptation: an insurance perspective

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Abstract As the world's largest industry, the insurance sector is both an aggregator of the impacts of climate change and a market actor able to play a material role in decreasing the vulnerability of human and natural systems. This article reviews the implications of climate change for insurers and provides specific examples of insurance-relevant synergisms between adaptation and mitigation in the buildings and energy sectors, agriculture, forestry, and land use. Although insurance is far from a "silver bullet" in addressing climate change, it offers significant capacity and ability to understand, manage, and spread risks associated with weather-related events, more so today in industrialized countries but increasingly so in developing countries and economies in transition. Certain measures that integrate climate change mitigation and adaptation also bolster insurers' solvency and profitability, thereby increasing their appeal. Promising strategies involve innovative products and systems for delivering insurance and the use of new technologies and practices that both reduce vulnerability to disaster-related losses and support sustainable development. However, climate change promises to erode the insurability of many risks, and insurance responses can be more reactive than proactive, resulting in compromised insurance affordability and/or availability. Public-private partnerships involving insurers and entities such as the international relief community offer considerable potential, but have not been adequately explored.

Keywords Energy efficiency · Climate change · Insurance · Risk management · Economic development

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1 Introduction

The insurance sector¹ integrates risks of extreme weather events across virtually all sectors of the economy. The core business of insurance, as well as the sector's activities in financial services and asset management are vulnerable to climate change (Table 1) (Mills 2005a). Structural changes in the insurance market could erode the market share for individual companies, and even lead to industry-wide contraction. Meanwhile, insurers not responding as expected by their customers will face reputational risks. As such, insurers are both impacted by, and stand to be a central actor in responding to climate change (Vellinga et al. 2001; Mills 2004). Until recently, the insurers' interest was seen as largely a European phenomenon. However, during the 2005–2006 period, the world's largest insurer (AIG 2005) and insurance broker (Marsh 2006)—both based in the United States—expressed deep concern about anthropogenic climate change, and the U.S. National Association of Insurance Commissioners (NAIC) formed an Executive Task Force to study the problem.

The argument has been made that insurance can play a substantial role in managing and spreading risks associated with increasing extreme weather events, both because of its financial capacity and its ability to encourage loss-reducing behaviors more effectively than public-sector efforts (World Bank 2002). By pooling risks among all those insured, insurers reduce the potential economic exposure of any individual or firm to a manageable level. This approach to risk spreading helps ensure that funds are available to pay for losses.² In addition to pooling risks, insurers can serve as proactive risk managers, e.g., by endorsing (or requiring) loss-prevention behaviors or technologies. Precedents include insurers' historical role in creating building codes, fire departments, and product safety labeling such as that performed by Underwriters Laboratories or Factory Mutual (Mills et al. 2001).

Furthermore, insurers can take modest steps to promote practices that simultaneously contribute to loss-prevention and enhance sustainability, particularly in energy use and management (Mills 2003a), e.g. by promoting distributed electricity generation to reduce risks of power disruptions and energy-efficiency strategies that reduce vulnerability to freeze damage and provide off-grid lighting or water purification (which are important in the context of disaster recovery). By helping spread the risks and costs of damages and by fostering disaster resilience in the face of rising losses, the insurance industry can help build and safeguard adaptive capacity in the ace of climate change while mitigating the core business risks posed by increasing greenhouse gas emissions.

While the majority of economic impacts from weather-related natural disasters and insurance payouts for such losses are today located in industrialized countries, those in developing nations and economies in transition (referred to together as "emerging markets" by insurers and in this article) are significant and growing relatively quickly. For

² Of course, insurers can become insolvent (bankrupt) following catastrophic events (Mills et al. 2001) although this is the exception to the rule, and solvency is less of an issue for insurers than for individually "self-insured" households or businesses.



¹ Unless otherwise noted, the terms "insurance" and "reinsurance" are used interchangeably in this report. Reinsurance is the purchase of insurance by insurers, typically for losses in excess of a pre-agreed amount but also on a proportional basis, and is the means by which many insured risks (both life and non-life) are ultimately distributed (Reitz 2003). Because a given reinsurance company will assume risks from thousands of insurers around the globe, reinsurance is an inherently global segment of the industry. The world reinsurance market is projected to nearly double from \$106 billion in premiums in 1995 to \$194 billion in 2010 (Duffy 2001).

Table 1 Climate-change threats and opportunities for the insurance industry

Financial sector activity	Threat	Opportunity
General financial services	New and existing markets become non-viable as climate change increases regional exposures	New markets/products related to mitigation projects/processes
	Macroeconomic downturn due to actual impacts	New markets/products related to adaptation projects/processes
	Compounding of climate change risk across entire portfolio of converging activities (asset management, insurance, reinsurance)	Public/private partnerships for commercially non-viable markets
	Unforseen changes in government policy	Technology insurance and/or contingent capital solutions to guard against non-performance of clean energy technologies due to engineering failure
Property/ Casualty Insurance	Physical damage to insured property from extreme/more frequent weather events, compounded by unmanaged development, resulting in volatile results and liquidity and credit rating problems	Increases in demand for risk transfer and other services as weather risks increase
	Increased risk in other lines of business (e.g. construction, agriculture, transport, liability)	Insurance of mitigation projects
	Increases in population and infrastructure densities multiply the size of maximum potential losses from extreme weather events	Innovative risk transfer solutions for high-risk sectors
	Regulatory risk	Proactive responses
Life/Health Insurance	Increased risk to human health (thermal stress, vector-borne disease, natural disasters).	Increase in demand for insurance and risk-management products as human health risk rises
Other	Business interruption risks becoming unpredictable and more financially relevant	Collaboration with other sectors in pooling capital
	Disruptions to construction/transportation sectors	Microinsurance
	Increased losses in agro-insurance	Weather Derivatives, CAT Bonds, etc.
	Political/regulatory risks surrounding mitigation	
Asset Management	Hidden GHG liabilities impair market values of securities	Investment in climate leaders and best-in-sector securities
	Insurer-owned or -occupied real estate impaired by weather events and increased energy costs	Innovative climate-related theme funds
	Potential absence of property insurance	Consulting/advisory services
	,	Hedge funds investing in GHG credits

Source: Adapted from UNEP and Innovest (2002)

these reasons, this article gives special emphasis to the problems in opportunities in these regions.

Three key types of activities could support the coupling of insurance and climate change adaptation:



- Generating information, training, and analysis to help make vulnerable markets attractive (i.e., less risky) for insurers;
- Identifying and deploying sustainable technologies to help simultaneously adapt to and mitigate natural disasters; and
- Fostering innovative insurance products and financing mechanisms to increase this form of risk spreading.

A major challenge lies in setting priorities and developing the public-private partnerships necessary for success.

The objectives of this article are:

- To describe the insurance market's global role in risk spreading as well as its own vulnerabilities to climate change.
- To establish the ability and rationale for insurers to engage in climate change mitigation and adaptation.
- To explore a subset of potential activities that simultaneously embody both mitigation and adaptation benefits.
- To identify potential avenues of involvement for insurers—as well as the limitations—and recommendations for cultivating effective partners among insurers and public-sector entities.

2 The insurance sector can play a material role in decreasing society's vulnerability to weather-related natural disasters while supporting its market objectives and sustainable development

From 1980 through 2003, the economic costs of "all" weather-related natural disasters totaled \$1 trillion (\$2003), divided approximately 40/60 between wealthy and poor countries, respectively (Munich Re 2004). Between 1980 and 2003, insurance covered four percent of the total costs of weather-related disasters in low-income countries and 40 percent in high-income countries (Figs. 1, 2). Of note, insurance payments associated with these losses in emerging markets were three-times the amount of international aid provided for these events, and availability and use of insurance is growing while international aid levels remain roughly level. Insurance is thus a promising vehicle for complementing international aid and improving adaptive capacity in wealthy and poor countries alike.

Nonetheless, the penetration of insurance in emerging markets is low compared to that in industrialized countries. Insurance premiums in emerging markets as of the year 2004 totaled approximately \$372 billion (up 18% from the prior year), or 11 percent of the global market (Figure 3). As will be discussed below, the lines between "North" and "South" are becoming blurred with the globalization of the insurance market.

Traditional responses to the impacts of extreme weather events are critical but woefully inadequate (even in wealthy nations, as evidenced in the wake of Hurricane Katrina). International aid today offsets only one percent of total weather-related disaster costs in emerging markets and is consistently short of the assistance requested by impacted

³ This includes "large" and "small" events, as defined by insurers, but does not in fact fully capture all events. For example, the Property Claims Service in the United States only counts events that result in over \$25 million in insured losses, effectively including all losses from events such as lightning strikes, soil subsidence, and small storms.



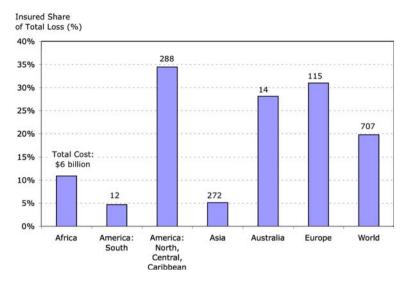


Fig. 1 A greater share of weather-related losses are insured in mature markets than in emerging markets (1985–1999). *Source*: Munich Re (2002)

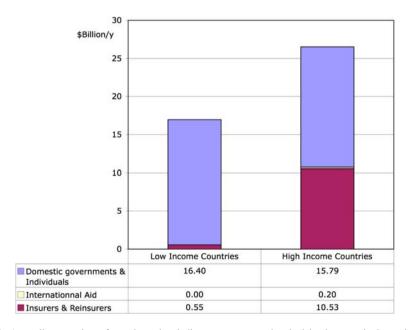


Fig. 2 A small proportion of weather-related disaster costs are absorbed by insurers in lower-income countries. *Notes*: Periods over which yearly averages are determined: Total: 1980–2003, Insurance: 1980–2003, AID: 1992–2003. sources: http://www.reliefweb.org (disaster relief); Munich Re 2004 (insurance and total economic of \$100/capital-year or less). Value for domestic governments & individuals is the residual. Aiddonors include those tabulated by OCHA: UN Agencies, donor governments, international organizations, the Red Cross, and NGOs (excludes purely millitary aid)



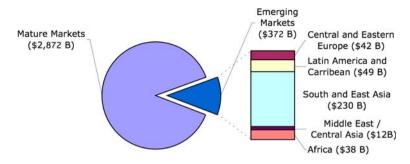


Fig. 3 Eleven percent of the \$3.2 trillion/year global insurance market is in developing countries and economies in transition: 2004. *Source*: Swiss Re, Economic Research & Consulting, Sigma No. 2/2005 [Swiss Re (2005)]. Includes property/casualty and life/health insurance

countries. With the rate of weather-related losses is increasing dramatically, rising naturaldisaster costs in aid-receiving countries, and growing demand for other forms of aid (e.g. due to civil conflict), relief aid is unlikely to absorb a greater share of the costs of natural disasters in the future.

While there is significant potential for constructive involvement of insurers in the response to climate change, there is also a host of socially undesirable ways that insurers may react. These include elevating prices without offsetting efforts to promote risk management, excluding specific hazards, withdrawing from at-risk market segments, raising deductibles, limiting maximum coverage, and non-renewal of existing policies.

Although insurance is not a panacea for the problems posed by weather- and climate-related risks—it is only one element in a patchwork of important actors—it can help manage costs that cannot be addressed by international aid or local governments or citizens. Almost all "lines" of insurance are vulnerable to climate risks, whether they are direct property losses from natural hazards or business interruptions from the disruption of electricity grids or environmental liability claims caused by water contaminated by flood-related runoff from farms or waste-disposal sites. The penetration of insurance varies considerably around the world, as does the type and scale of disasters (Fig. 4).

The ability to adapt to extreme weather events is lowest in the poorest segments of society and in countries where resources, information, and skills are limited; technology is often unavailable; institutions are unstable or weak; and empowerment and access to resources is inequitable (Smit et al. 2001). Properly applied, insurance can play a particularly important role in this setting. These areas are high priority for insurers, because, although not today "large" markets, they are growing at approximately twice the rate of insurance markets in industrialized countries, and the vulnerabilities to climate change are substantially higher—by orders of magnitude in some instances. However, climate change could also introduce a high degree of actuarial uncertainties, resulting in the contraction of this growth and the loss of social and economic benefits that insurance would otherwise afford.

According to observations from the Emergency Events Data base (EM-DAT), compiled by the U.S. Agency for International Development Office of Foreign Disaster Assistance (USAID/OFDA) and the Center for the Research in the Epidemiology of Disasters



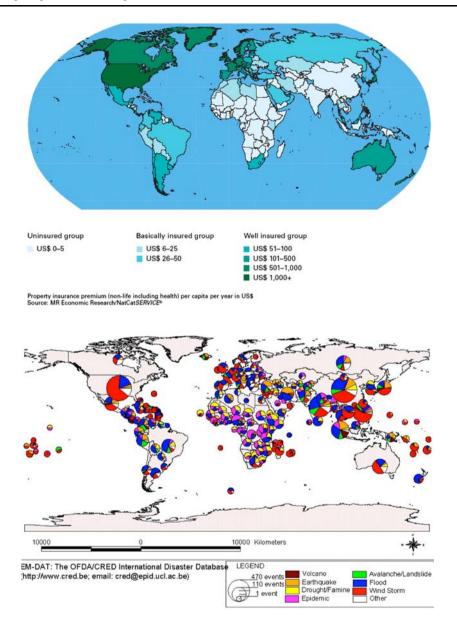


Fig. 4 (a) The use of insurance varies widely around the world, (b) The type and scale of natural disasters are distributed unevenly: 1975–2001

(CRED), the number of weather-related natural disasters has risen sharply during the past 50 years (Fig. 5).⁴ According to CRED, the incidence of weather-related disasters per decade has risen from approximately 100 to 1,600 events during the past 50 years in

⁴ As with all such datasets, caveats apply with respect to uniformity over time in data collection methods, data quality, comprehensiveness, etc. A discussion of the longitudinal quality and consistency of the EM-DAT data provided by Brooks and Adger (2003) concludes that analyses based on data from 1970 forward are "fairly robust."



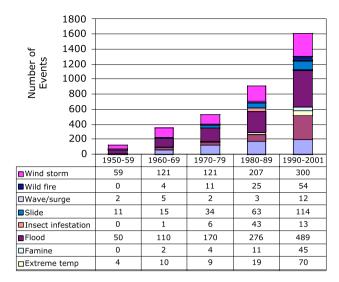


Fig. 5 The frequency of weather-related disasters has risen in less developed countries: 1950–2001. Sources: OFDA/Center for Research in the Epidemiology of Disasters (CRED) "Natural.xls" Intl database of Disasters (http://www.cred.be/emdat/intro.html) and U.S. Census Bureau's International database (http://www.census.gov/ipc/www/idbagg.html). From analysis completed by Padco's Climate Change Solutions Group for USAID's Global Climate Change Team. "Population Impacted" includes those persons that have either been killed, injured, left homeless, or otherwise adversely affected

less-developed countries, with the number of people impacted or killed per decade rising steadily from 15 million during the 1950s to four billion during the 1990s. These trends are a combined result of changes in the nature of natural hazards and demographic factors which bring more people into harm's way.

Although all losses have increased (and become more variable) in absolute terms, the rise in the relative incidence of weather-related events (such as wildfire, extreme temperature episodes, and epidemics) has significantly outstripped those due to non-weather-related ones (such as volcano eruptions or earthquakes), as well as overall economic activity (Fig. 6) (Mills 2005a). The costs of so-called "man-made catastrophes" have also risen more slowly than those of natural catastrophes. Note that these increases have occurred in spite of significant investments in loss control, ranging from flood-plain management to improved building codes to increasingly sophisticated early warning and evacuation strategies, as well as insurer efforts to reduce their own exposures (e.g. via increased deductibles and lower limits on payouts).

Even in wealthy nations, governments are increasingly seeking to limit their financial exposures to natural disasters (e.g., the U.S. National Flood Insurance Program will pay out no more than \$250,000 per loss per household (McDonald 2003)). The problem is worse in emerging markets where governments are hard-pressed to absorb the large costs of natural disasters (which are unpaid by insurers, relief aid, or individuals). Disruption of economic activity and diversion of government funds to prepare for and recover from natural disasters constrains development. Insurance is the only source of adaptive capacity that is clearly increasing.



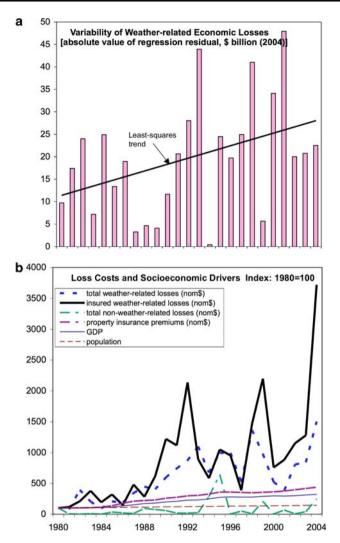


Fig. 6 (a-b). Variability of losses is increasing (a) and the magnitude is growing faster than population or the economy. *Source*: Mills (2006)

3 The global insurance market offers considerable adaptive capacity

Worldwide, insurance companies collected \$3.2 trillion in premiums in the year 2005 or about eight percent of global GDP. ^{5,6} To put the size of the insurance industry in perspective: comparing the industry's revenues to national GDPs shows that the industry is equivalent to the third largest country in the world. The insurance sector is the world's largest industry.

⁶ Data presented in this report represent western-style insurance and do not include the premium-equivalents that are collected from alternative systems, such as *Takaful* methods used in the Muslim world or socalled "self-insurance" which is often formalized and represents considerable capacity.



⁵ Detailed country-by-country statistics (in U.S. dollars and local currencies) are published in Swiss Re's annual "World Insurance" reports (e.g., Swiss Re 2004).

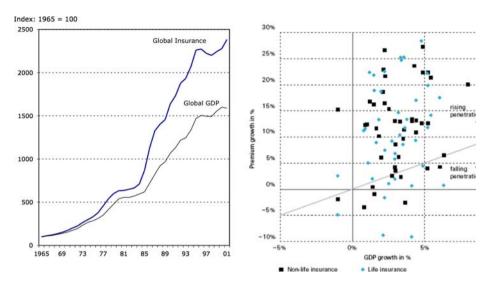


Fig. 7 (a) Insurance demand is growing faster than GDP, particularly in emerging markets. *Source*: Swiss Re, Economic Research & Consulting; WEFA. *Notes*: These data exclude health and life insurance premiums and losses. Non-inflation-adjusted economic data are shown in relation to GDP. Inflation-adjusted economic losses from catastrophic events rose by 8-fold between the 1960s and 1990s and insured losses by 17-fold. [Sources: Natural hazard statistics and losses from Munich Re, NatCatSERVICE; Premiums from Swiss Re, Sigma] (Mills 2005a)

The mix of life-health versus property-casualty insurance varies widely among nations, with a 40/60 ratio on average, but the magnitude and growth rates of life insurance tend to be greater than those of property insurance (Mills 2004). In response to the confluence of economic growth, population growth, and market liberalization, the insurance sector is growing particularly rapidly (significantly faster than GDP) in emerging markets (Fig. 7).

At current growth rates, emerging markets will represent half of world insurance premiums by the middle of this century.

In both developing and industrialized countries, the penetration of insurance by type of event varies, with most coverage for storms and least coverage for flood⁸ and "other" events such as drought and wildfire. Approximately 45 percent of global storm-related losses were insured over the period 1985 to 1999 versus five percent of flood and 13 percent of "other." Some events go uninsured; e.g., global losses from drought and heat wave reached nearly \$7 billion in 2002, and little or none of these losses was insured (Best's Review 2003). Damages from mudslides are rarely if ever insured.

⁸ There is a common misconception that floods are entirely uninsured. Typically one-quarter of flood losses are paid by insurance, depending on the country in which they occur and the nature of the impacts. More than half of the economic losses from the massive Central European floods in 2002 were insured (Best's Review 2004). Government flood insurance in the U.S. only applies to residential and small commercial properties. Definitional ambiguities often classify flood-related losses as (insured) "storm" losses (Swiss Re 2003b).



⁷ For the period 1980–1998, South and East Asia was the fastest growing region with 15 percent per year growth for non-life insurance and 25 percent for life insurance. In Latin America, growth was 10 percent and 15 percent, and in Africa five percent and 15 percent, respectively. Trends in Eastern Europe were highly erratic for the post-1992 period for which data are available (Swiss Re 1999).

The demand for weather-related insurance is growing. Expanding market segments include weather-derivatives applicable to utilities, crop production, and other weather sensitive businesses; insurance for the diverse impacts of power outages; and property insurance in areas with wildfire risk. Because of growing demand and affluence in developing countries and economies in transition, insurers from industrialized countries are rapidly moving into those markets. Insurance systems, however, are already challenged by natural disasters in wealthy countries where risk management and disaster preparedness are well developed. The outcome of this tug of war is key to determining the ultimate global role that insurers will seek to play in absorbing the rising costs of natural disasters.

4 The potential for new patterns of extreme events resulting from climate change will likely increase demand for insurance while challenging the industry's ability to assume new risks

Insurers have expressed concern about climate change since the early 1970s (Munich Re 1973). Since that time, insurers have seen property-casualty claims from natural disasters (corrected for inflation) rise considerably compared to other losses. Corresponding life-health insurance loss trend data are generally not available, owing largely to their diffuse, non-catastrophic nature. Coupled with the growing rate of losses, insurers expanding into emerging markets also encounter actuarial uncertainties posed by the relative volatility of weather events (see Fig. 8) as well as the greater exposures and vulnerabilities of emerging markets to these disasters. As a result, the "risk premium" is higher and, thus, so are prices and price volatility.

Regardless of the proportionate attribution of climate change to human activities or natural variation in weather-related losses, the observed increase in uncertainty regarding the intensity, frequency, location, and correlation of losses among of extreme weather events confounds the fundamental actuarial processes that underlie well-functioning insurance markets. Increased uncertainty can thus call into question the fundamental insurability of certain risks, which may have the result of limiting the affordability and/or availability of insurance (Mills et al. 2005). Climate change is a significant concern for both the property-casualty and life-health segments of the industry, perhaps more so for the latter segment because of its relatively larger size and growth rate, and the less well-understood implications of climate change for morbidity and mortality (Epstein and Mills 2005).

Limitations to insurance's effectiveness in addressing these issues also include the short timeframe of insurance contracts and the ease with which insurers can withdraw from or increase prices in markets perceived as overly risky. Moreover, the insurance industry itself is vulnerable to extreme weather events and climate change, and its capacity to absorb risk varies depending on recent losses and other market factors. Nonetheless, insurers have historically used risk management and loss-prevention techniques to reduce business risks in particular market segments, while growing their business even in the face of increasing risks.

5 The consequences of extreme weather events are becoming increasingly globalized, in part because of the structure of insurance markets

Insurance is an integral part of the trend toward globalization, and U.S.-based insurers are leading the way, as measured by the magnitude of their participation in foreign



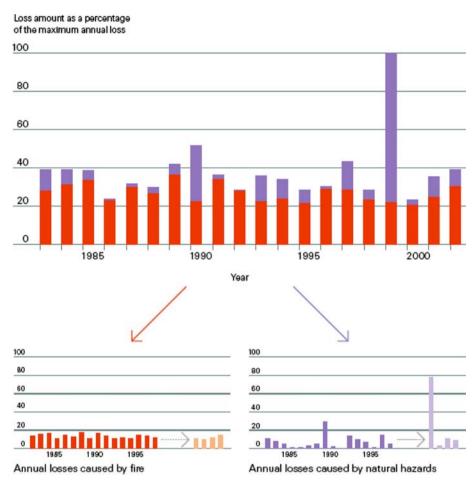


Fig. 8 Insured losses from natural hazards are less predictable than conventional losses (Central Europe: 1983–2002). *Source*: Swiss Re 2002g

markets. Current trends toward deregulation and liberalization in Asia (particularly China and India) and Eastern Europe, as well as increasing wealth are fueling the growth of insurance.

Experience to date suggests that participation of foreign insurers will be important for the development of new insurance markets in developing countries and economies in transition. A statistical review by Swiss Re (2000) found that growth of foreign insurers' premiums in emerging markets averaged more than 20 percent per year during the 1990s. During the late 1990s the U.S. alone was collecting approximately \$40 billion in premiums for policies placed overseas, with an average annual growth rate of 10 percent between 1990 and 1998 (III 2003). Between 1990 and 2000, the market share of insurers that were

⁹ The leading insurers in this category include Aetna, AIG, CGU, Chubb, Cigna, Metropolitan Life, New York Life, and Prudential (Swiss Re 2000).



either partly or fully foreign owned tripled in Latin America and Central and Eastern Europe¹⁰ to 47 percent and 41 percent, respectively, and to 12 percent in Asia.¹¹ Although they enjoy the considerable economic potential of emerging markets, foreign insurers must also help pay the growing costs of extreme weather events, including the costs of flood, drought, wildfire, and a wide range of health impacts.

Insurers domiciled in industrialized countries are also vulnerable to extreme weather events elsewhere through insurance of property or activities associated with international trade or commerce, or overseas assets of their customers. The types of coverage affected range from political risk insurance to marine insurance and coverage for other weathersensitive energy-sector activities such as those associated with the oil trade (SAI 2000). Natural disasters can also have ramifications for distant economies by disrupting supply chains and other increasingly interconnected market systems. In addition, insurance observers note that emissions could result in liabilities for polluting companies, which could, in turn, manifest in on- or off-shore product liability, business interruption, or Directors and Officers insurance exposures (Aldred 2004a, b).

Meanwhile, as noted earlier, international aid—a key pathway through which extreme-weather risks are becoming globalized—has not kept pace with the growth in demand for natural disaster relief. Importantly, international aid has been flat in the past two decades (at approximately \$60 billion per year) and declining as a percentage of donors' GDP, while the inflation-corrected economic costs of natural disasters has increased eightfold. Moreover, most (if not all) aid goes toward recovery, and little is directed to proactive and preventive measures. In addition, foreign policy considerations mean that the majority of aid is designated for events other than natural disasters.

6 Insurance for extreme weather events can be coupled with strategies that contribute to sustainable development and enhance disaster resilience

Considerable thought has been devoted to identifying disaster-management strategies that also support sustainable development. Examples include protection of mangroves, reefs, and beaches to reduce storm surges or watershed management practices that reduce flood and landslide risk (Aalst and Burton 2002).

Less effort has been devoted to identifying strategies that also reduce greenhouse-gas emissions (Mills 1996, 2003a). These strategies involve an intriguing combination of adaptation and mitigation; e.g., methods of reducing the vulnerability of buildings and their occupants to urban heat-island effects and acute heat catastrophes also tend to increase energy efficiency, thus curtailing greenhouse gas emissions. The balance of this section presents examples for which there is a natural involvement by the insurance industry. The items are grouped into two overarching categories: Energy Systems and Agriculture, Forestry, and Land Use. A summary is given in Table 2.

¹¹ Chile and Mexico have the highest penetrations. In Asia, the greatest shares are found in Malaysia, the Philippines, Indonesia, and Singapore (Swiss Re 2000). In Central and Eastern Europe, Hungary and Poland have the highest penetration of foreign insurers.



¹⁰ For data on additional Central and Eastern European countries, see Munich Re (2000) and Swiss Re (2001).

Table 2 Characterization of adaptation-mitigation co-benefits, and insurance lines of business effected

Sector > Strategy	Mitigation benefit	Adaptation benefit	Types of insurance benefits
Energy sector—demand	l side		
Energy efficiency generally	Reduced energy use and associated emissions	Grid reliability, reduced backup generation requirements during outages	Business interruption, contingent business interruption, service interruption, boiler and machinery, perishable commodities loss control
Natural ventilation, daylighting	Reduced energy use and associated emissions	Allows continued facility occupancy during power outages	Business interruption
Insulated ceilings in cold climates	Reduced heating energy use and associated emissions	Ice dam mitigation and extended habitability of structures during natural disaster	Property, business interruption
Heat island mitigation, e.g. via reduced roof and pavement albedo and urban forestry	Reduced air- conditioning energy use and associated emissions, increased earth albedo	Extended habitability of structures during heat waves, moderation of precipitation (urban trees) and reduced flash flooding, reduced smog formation due to lower ambient temperatures	Health, Life, relocation and additional living expenses, business interruption
Efficient grid- independent lighting	Reduced electricity use and associated emissions	Disaster recovery	Business interruption
Efficient windows	Reduced space-cooling energy use and associated emissions	Improved fire-resistance and reduced vulnerability to wind-blown debris	Property
Energy sector—supply	side		
Renewable energy systems	Reduced fossil energy use and associated emissions	Grid reliability, generation diversity yields robustness during outages, reduced vulnerability to cooling water scarcity	Business interruption, service interruption, cyber-risk insurance (data loss), worker's compensation, property loss, liability, perishable commodities loss control
Distributed energy systems	Reduced electricity transmission losses (and thus energy use)	Grid reliability, generation diversity yields robustness during outages, reduced vulnerability to cooling water scarcity	Business interruption
Hydroelectric systems	Reduced emissions	Flood control	Property, health, life
Biomass energy plantations	Carbon sequestration	Watershed management	Property, health, life
Agriculture, Forestry, as	nd Land Use		
Agricultural soil management	Carbon sequestration in soils	Enhanced drought-resistance	Crop
Land restoration and afforestation	Carbon sequestration	Reduced flood/mudslide risk	Property



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Sector > Strategy	Mitigation benefit	Adaptation benefit	Types of insurance benefits
Mangrove protection/ restoration	Carbon sequestration	Enhanced flood and tidal- surge resistance	Property, health, life
Health (Human and Ot	her Systems)		
Improved forest management	Reduced wildfires (carbon emissions)	Reduced fire risk and standing-water habitat for malaria vectors, flood control, reduced vulnerability to forest pests, retention of disease vectors (e.g. bats—Nipah virus) otherwise hazardous to humans	Property, health, life
Ultraviolet water disinfection	Reduced commercial energy use and associated emissions, reduced deforestation	Ability to respond to water quality crises following extreme weather events	Health, life

6.1 Energy systems

Perhaps counter-intuitively, energy systems can grow more vulnerable to extreme weather events as economies become more developed and affluent. Energy infrastructure—particularly electric power and oil production systems—is distinctly vulnerable to natural disasters, as well as to gradual climate changes, with increasing consequences for insurers. As discussed below, climate change mitigation strategies in the energy sector can also increase resilience to weather-related losses, i.e., there are numerous synergistic interactions between adaptation and mitigation.

The energy services provided by centralized systems are particularly vulnerable because, for example, a single disruption to a power plant or refinery affects a very large population of end users and because damage to the transmission or distribution side can isolate an otherwise functioning central facility from end-users. The European winter storms of 1999 of caused \$2.5 billion of equipment damages to the French electric utility (Munich Re 2003). Soil subsidence—a less dramatic but equally worrisome phenomena caused by the melting of permafrost is a risk to gas and oil pipelines, electrical transmission towers, nuclear power plants, and natural gas processing plants throughout the arctic (Nelson et al. 2001). Ice Storms can cause electrical system disruption, as was witnessed in the storm in the Northeast US in 1998, an El Nino year (Lecomte et al. 1998). This particular event was the most costly in the history of the Canadian insurance industry, the primary element of which was electric power disruptions (Munich Re 2003). During the catastrophic European heat waves of 2003, nuclear power plant activity had to be curtailed in eight countries because of elevated cooling-water temperatures (Munich Re 2004; Mills et al. 2005). Reduction in water availability under climate change in certain regions could also hamper hydroelectric as well as thermal power generation, as was seen in Brazil in 2001/2002 when a 70-year drought threw the country's hydro-dependent power sector into acute shortage conditions (Munich Re 2003). Elevated water temperatures cause reduced power plant efficiencies and trigger plant closures in response to unacceptable



environmental consequences in water bodies to which cooling water is discharged. Natural disasters can also cause primary energy supply disruptions (damages to dams and other energy infrastructure, disruptions to shipping, etc) that, in turn, tend to manifest in elevated consumer prices.

These events have material business consequences. The Louisiana subsidiary of Entergy was rendered insolvent due to a combination of physical damages from Hurricane Katrina and the subsequent protracted lost revenues. Hurricane Katrina devastated oil production infrastructure in the Gulf of Mexico, which led to substantial insurance price increases and reduced availability within the energy sector. Business interruptions take the form of lost sales (which contributed to the bankruptsy of Entergy in Louisiana). For reference, in France alone, the European heatwave of 2003 caused the loss of 200 nuclear reactor days, 20% loss of hydro generation, and costly purchases of wholesale power imports, all of which contributed to explosive spot prices. Elevated temperatures also reduce the efficiency of power transmission, due to increased "I²R" losses, resulting in lost revenues to utilities.

New energy systems will also bear insurance and risk management considerations, such as liability and physical risks associated with carbon capture and sequestration (CCS) technologies (Wilson and de Figueiredo 2006; Wilson et al. 2003), hydrogen (Moy 2003), or renewed use of nuclear power. New technologies are intrinsically harder to insure, given the lack of historical performance track record and loss profiles.

End-use loads "downstream" from energy production and distribution, particularly space-cooling, are also vulnerable to gradual changes in average temperatures. The net effects of changing cooling and heating loads must be accounted for in residential settings, while cooling loads are the driving factor in commercial buildings and most industrial facilities. Importantly, changes in maximum temperatures—likely to be proportionately higher than changes in average temperatures—drive electric system peak loads.

Power outages are an emerging insurance risk for end users as well as energy suppliers, witnessed by the 2003 outage in North America which left 50 million people without power, resulting in up to \$10 billion in total losses (Fletcher 2004) and insured losses of about \$3 billion (Munich Re 2003). Between 1982 and 2002, 62% of the outages on the wholesale grid were attributable to weather-related events (Mills et al. 2005). In 1999, a single lightning strike put 80 million people in darkness in Brazil. A recent survey found that power outages cost half of the companies surveyed \$50,000 per hour of downtime, and over \$250,000 for the top quartile (Risk Management 2003). Italy experienced an even larger outage in 2003, with other major outages in London and parts of Scandinavia (Wade 2004). Losses can range from various forms of business interruptions; to property losses from consequent fires (61 more fires than normal during the 2003 US blackout), data loss, equipment damage from power surges, and loss of perishable refrigerated products; to injury from evacuations; to liability for power suppliers deemed to have been able to avert the loss (Eto et al. 2001). Business interruptions are particularly significant, e.g. Ford Motor Company stated that more than half of its 44 plants in North America were shut down by the outages of 2003, and others (out of the area of the outage) were adversely impacted by disruptions to supply lines. All other major car manufacturers in the Detroit area were also shut down (Bradford 2003). The Taiwan earthquake of 1999 caused, among other things, insured losses of \$350 million due to the disruption of the semiconductor industry alone (Munich Re 2003). In Aukland, New Zealand, the largest heatwave since the year 1868 drove peak air conditioning demand, which, in turn, contributed to the collapse of electricity supply in 1998 after one of two major transmission cables was compromised (Munich Re 2003).



While arguably not as "brittle" as centralized energy systems, renewable systems can have their own vulnerabilities. Windstorm is a hazard for most renewable systems (whether centralized or distributed), particularly wind-power systems, which are intentionally placed in the path of the greatest wind corridors (UKCIP2003). Conversely, wind resources could shift thereby stranding prior investments. Biomass-based systems are vulnerable to interruptions of fuel supply due to drought, wildfire, flooding, infestations or disease, and other hazards impacting fuel distribution or growing areas. Hydroelectric power systems are clearly dependent on precipitation, runoff conditions, and siltation rates for which they are designed, and may thus be impacted by changing climatic conditions, while flooding can cause damage to hydroelectric infrastructure.

Energy systems in developing countries are probably the most vulnerable. Issues range from loss of cooling and heating biomass fuels due to gradual or abrupt events, to disruptions of commercial energy sources (electricity, oil, etc.). Associated human health consequences are more acute, e.g. due to food and water supply disruptions and reduced habitability of structures or provision of medial services in the absence of energy services. Drought in Ghana in 1982 led to reduced hydroelectric output, which, in turn resulted in the shutdown of an aluminum smelter. Economic costs were estimated at \$557 million (Munich Re 2003), a significant sum for such a poor country. Drought in Tanzania led to routine 12-hour blackouts in early 2006.

The preceding caveats notwithstanding, adaptive capacity may be enhanced by strategically placed distributed power generation and renewable energy systems. Similarly, increases in energy efficiency at the point of end-use decrease average and peak demands on electricity grids. Goldman et al. (2002) found that Californians reduced electricity usage by 6% and monthly peak demand by 8% in response to the impending power outages of summer 2000, and even more the following summer. This demand response—which translated into 50–155 h of avoided rolling blackouts—contributed to avoiding an estimated economic loss as high as \$20 billion.

Lastly, the synergisms between energy-efficient strategies and climate change adaptation have been treated in some depth elsewhere (Mills 2003c). These include concepts such as reducing rooftop ice damming with better insulation, the fire-resistance of energy-efficient window systems, and reduced risk of mortality or morbidity from urban heat island management. Following are illustrative examples of how this thinking can be extended to insurance-relevant applications in emerging and industrialized markets.

- Mitigate urban heat islands. Increasing the reflectivity of roads and rooftops lowers ambient urban air temperatures, which reduces smog formation and lowers the risk of mortality during heat catastrophes. The need for mechanical air conditioning is consequently reduced. Moreover, urban trees reduce runoff and hence the risk of flash-flooding. The Earth's overall albedo is also increased, reflecting a larger proportion of incoming solar radiation back to space.
- Deploy efficient refrigeration systems. As a prominent example of the importance of multiple small and dispersed losses, one of the most common causes of losses during the Ice Storm of 1998 in Canada was perished food in residential refrigerators (insured up to CD\$1000 in many homes) (Munich Re 2003). Similar risks apply for commercial refrigeration, especially where contents are highly valuable, as in the case of pharmaceuticals. Energy efficient refrigeration systems maintain temperature significantly longer during power outages, thereby reducing or eliminating losses.



Fig. 9 USAID "Warm-Dry Rooms" project



Warm-dry rooms in Kosovo helped residents remain in their homes throughout the winter (photo by Charles Setchell.

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- Support afforestation using biomass energy plantations. This would enhance renewable energy production, flood/landslide management, soil/water conservation goals, and carbon storage objectives.
- Deploy distributed renewable energy systems to enhance electricity-system reliability. Distributed renewable energy generation systems (e.g., micro-hydro, wind, solar thermal, and solar electric power) are largely invulnerable to grid and fuel-supply disruptions. In the wake of the massive U.S. blackouts of summer 2003, insurers acknowledged the potential benefits of renewable energy (Sullivan 2003). This is particularly important in light of an increased awareness of the risks of wide-area power outages and a trend towards reductions in business interruption insurance availability.

While the insurance market is still relatively small in the developing world, forward-looking insurers will see opportunities to improve disaster resilience through energy-related strategies.

Following are illustrative examples:

- Embed sustainable technologies in disaster recovery activities. USAID/OFDA's shelter specialist devised "Warm-Dry Rooms" for 22,000 families during the crisis in Kosovo between 1998 and 2000 (Fig. 9) (OFDA 2002). Warm, dry rooms were created in existing structures as an alternative to creating displaced-persons camps, thereby maintaining the cohesion of communities while providing employment to those



Fig. 10 Energy-efficient UV water disinfection system. Source: http://www.waterhealth.com/emergency_relief.htm



constructing the rooms. Augmenting such strategies with high-efficiency space-heating strategies would increase the number of families that could be served with finite heating-fuel supplies.

Promote energy-efficient water disinfection for disaster recovery. Approximately a decade ago, USAID provided seed funding to develop a new disinfection technology that would remove waterborne diseases using significantly less energy than traditional methods. The result was "Ultraviolet (UV) Waterworks." a small-scale system that can operate on or off of the electricity grid (Fig. 10). UV disinfection reduces pressure on fuel-wood resources, and thus is important to efforts to curb deforestation, which reduces carbon sinks and increases net emissions. ¹² Applications have also been seen in industrialized countries, where water supplies are also compromised during disasters where flooding mobilizes pollutants or power losses disrupt water delivery and wastemanagement infrastructure.

Incorporate low-power lighting systems in disaster relief, promoting independence from fuel-based lighting and batteries. Nearly two billion people are dependent on liquid fossil fuels for lighting, a source of approximately 200 million tones of CO₂ emissions annually (Mills 2005b). Supplies of these fuels can be easily disrupted during natural disasters, impeding the disaster-recovery process. New light-emitting diode (LED) technologies make it possible to provide high-quality grid-independent light supplies that are far more rugged, efficient, safe, and cost effective than versions currently in use (Fig. 11). These systems would be valuable in disaster-recovery situations (both for aid workers and for impacted citizens, in homes or in camps for dislocated people). Typical solar/fluorescent lighting systems are too expensive and have questionable durability in these contexts. Emergency lighting applications in industrialized countries would also help reduce business interruptions and injuries during evacuations by providing illumination for otherwise electrified homes and businesses.

6.2 Agriculture, forestry, and land use

Sustainable Forestry Practices: Wildfire Management, Flood Risk Reduction and Enhanced Hydroelectric Power Production. Many studies have linked environmental degradation (including deforestation) with increased vulnerability to natural disasters (e.g.,



¹² See http://eande.lbl.gov/IEP/archive/uv/index.html



Fig. 11 Solar-powered white-LED lighting system. Commercialized by Better Energy Systems, the *Solio* is a compact and rugged solar charger for cell phones and other hand-held electronics. Now being coupled with a WLED peripheral, it will provide a rugged and affordable lighting solution for applications in developing countries

hurricanes and mudslides) (IPCC 2001). Wildfires caused by slash-and-burn deforestation are both a source of net carbon emissions and a natural hazard for property and health. (See Portela and Aguirre 2000 for several examples specifically related to Cuba.) Indonesian wildfires (associated with drought) may have been associated with the spread of Nipah virus (via dislocated fruit bats moving into human settlements and agricultural areas).

In many parts of the world, deforestation has released silt into rivers that seriously impacts hydroelectric turbines and reduces reservoir capacity. If effectively managed, future increases in runoff could mean enhanced power generation. However, if runoff is a result of increased variability in climate (as expected under climate change), rather than increased average flows, more uncontrolled spills (floods) are expected. A watershed with diverse vegetation will more effectively buffer a reservoir from rapid influxes of runoff than will a deforested watershed, while maximizing carbon storage. If rapid influxes are prevented, the reservoir may be able to produce more power on an annual basis because operators can cycle more water through the turbines instead of spilling it during heavy runoff episodes. An important collateral benefit is that reduced siltation means overall storage capacity of the reservoir is maintained, preventing overflow flooding and extending the life of the facility.

There exists some precedent within the insurance sector for the aforementioned types of projects. Storebrand—Norway's largest insurer—has invested in sustainable forestry projects (Storebrand n/d). Similarly, in partnership with the Swiss Association for International Cooperation, Swiss Re contributed to the reforesting 650,000 trees in Haiti, ¹³ to help counteract the detrimental effects of deforestation and erosion on drinking water. To enhance storm surge protection, the Japanese insurance company Tokio Marine has supported projects that protect mangroves.

Dry-land farming adaptation in drought-prone regions to enhance food security, preserve water quality, and conserve carbon in soils. Agricultural soil conservation measures reduce runoff, erosion, and vulnerability to drought. Insurers could support these efforts by providing crop insurance to appropriate operations if there is none or reducing premiums if

¹³ http://www.swissre.com/INTERNET/pwswpspr.nsf/fmBookMarkFrameSet?ReadForm&BM=./all-docbyidkeylu/SBAR-59FLV7



crop insurance is already available. A similar approach could be explored for weather derivatives. USAID's Natural Resource Investment Fund Project (FIRENA) is reported to have conduted a successful pilot project in the Dominican Republic (Aalst and Burton 2002).

Wetland management and restoration. Hurricane Katrina drew significant attention to the consequences of chronic destruction of wetlands, and associated loss of storm-surge protection. Wetlands are significant sinks of carbon (although also a source of methane), they also provide coastal protection from storm surges and demark coastal territory not suitable for human settlement (Ramsar Convention on Wetlands 2002; IPCC 2001). Drainage of inland wetlands significantly increases the risk of wildfire. The loss of wetlands thus represents both a net emission of carbon to the atmosphere and a loss of adaptive capacity. In a worrisome feedback mechanism, wetlands are in turn expected to be adversely impacted by climate change (USGS 1997).

7 Innovative insurance products & financing

Insurers are, by definition, interested in preventing losses rather than paying to repair postevent damages. The availability, terms, and pricing of insurance can be crafted to send signals that encourage practices that enhance disaster resilience; this is often the case in advanced insurance markets (e.g., good-driver discounts). Practices that can be encouraged include the use of early-warning systems, building codes (and their enforcement), land-use planning, sustainable forestry, and the types of energy-related measures described in the preceding section that inherently improve disaster resilience, e.g., by reducing reliance on grid-based power. In addition, for the billions of people who have no insurance, new insurance products—e.g. micro-insurance—should be developed (World Bank 2000).

There are specific ways in which new or existing insurance products can be used to promote increased use of sustainable practices, as follows:

- Crop insurance, sustainable agriculture, enhanced food security and carbon sequestration. According to a UN presentation at the World Summit on Sustainable Development (UN2002) "in rural programmes and drought-prone areas, specific attention should be paid to food security and the promotion of agriculture techniques and inter-cropping that reduce hazard-related agriculture losses." Sustainable agriculture activities tend to increase carbon storage in soils, thus providing dual adaptation/mitigation benefits. New initiatives could foster such practices through linkages with either public- or private-sector-provided crop insurance.
- Weather derivatives and other hedging tools. A panel of insurers convened by the UN noted that climate change could offer opportunities for the weather-derivatives market (Zolkos 2002). Other observers have stated that weather derivatives may be preferable to traditional insurance in some cases, given the linkage to a predetermined trigger regardless of the scale or nature of damage, rapidity of payouts, etc. (Benson and Clay 2002). Investors in renewable energy technologies will be particularly interested in these products, as weather is a key determinant of performance and profitability (Aldred 2004a, b). However, serious concerns have been raised about the viability and credibility of the weather-derivative business model (Swiss Re 2002a), and a major case of fraud spanned several countries (McLeod 2003). Care should thus be taken in evaluating potential applications.



- Insurance for renewable energy systems. Capital projects, including those involving
 renewable energy, are vulnerable to natural disasters and other types of risks. Major
 insurers and brokers such as Aon (Aldred 2000) and Marsh (2006), are becoming
 involved in providing coverage and perhaps other forms of risk management to projects
 established to achieve greenhouse-gas emissions reductions. Swiss Re has investigated
 providing professional liability insurance to firms that provide verification and
 measurement services for carbon-trading arrangements (Sclafane 2001).
- Expansion of Markets for Energy-Savings Insurance (ESI). Insurers in North America have begun to provide what is known as "Energy-Savings Insurance" which addresses performance risks in traditional energy-savings investments by warranting performance in exchange for a premium (Mills 2003b). One benefit of ESI is that it can operate essentially as a loan guaranty in cases where debt service is indexed to the anticipated energy savings. This can translate into favorable borrowing terms. By analogy, AID's Development Credit Authority has guaranteed loans for energy efficiency, which has been seen as beneficial by local banks. There is a large potential for ESI in emerging markets (and analogous renewable energy and cogeneration performance insurance products), especially because performance risks could be particularly high there.

8 Potential for public-private partnerships

Some have argued that insurance will drive many necessary adaptations to climate change (Milne 2004) and that the industry could become a major force in climate change mitigation strategies as well (Mills 1996). While they will not act unilaterally, insurers can promote joint mitigation/adaptation technologies and practices in a variety of ways. The most direct way is through rewarding those who adopt risk-reducing technologies and practices, using financial incentives in the form of lower premiums, higher deductibles, etc. There are other methods as well, such as channeling information to insurance customers and promoting improved building codes and land-use planning (both of which have a long history of insurer involvement). There is considerable precedent for such activities (Mills 2003a).

An overarching strategy is to create public-private partnerships to help condition markets to manage risk so that insurance or insurance-like risk-spreading systems can be introduced successfully and in a sustainable fashion (Hoff et al. 2003). Figure 12 is one such conceptualization of the flow of knowledge and financial resources among diverse actors.

Public-private partnerships can enhance the effectiveness of insurance and increase the pool of people who have access to it. In a relatively straightforward example, commercial insurance companies in the U.S. are introducing flood insurance to complement that provided by government programs (McDonald 2003). More innovative examples include systems for delivering insurance to the poor (e.g., micro-insurance or small-denomination/low-cost weather hedges for farmers in developing countries) combined with technologies and practices that simultaneously reduce vulnerability to disaster-related insurance losses and support sustainable development and reductions of greenhouse gas emissions. A strategy combining these elements was piloted in the Caribbean where USAID's Office of Foreign Disaster Insurance and NGOs provided trained homebuilders to construct hurricane-resistant housing, banks provided financing for construction, and insurers made coverage available where it had not previously been (Box 1). Insurers have stated their



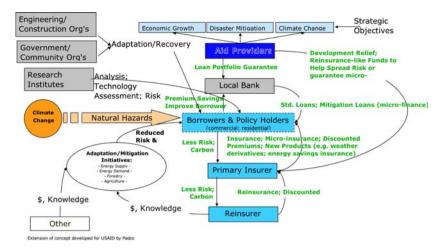


Fig. 12 New public-private systems could couple climate change adaptation-mitigation, economic development, and risk management

Box 1 "Lessons Learned": The Caribbean Disaster Mitigation Project (CDMP)

Initiated in 1993, CDMP is a project of USAID/OFDA, implemented in several countries by the Organization of American States, to promote sustainable public/private disaster mitigation mechanisms that lessen loss of life, reduce potential damage, and shorten disaster-recovery periods. Project activities included support for national insurance associations in organizing technical conferences, disseminating hazard and risk information, and producing hazard and risk maps and information to promote safer location of development (USAID-OAS 1996). Beginning in 1998, the Barbados-based United Insurance began a program in which homeowners and businesses could qualify for significant reductions in insurance premiums if they retrofit homes and buildings to better withstand hurricane wind forces. The project operated in Dominica, Saint Lucia, Saint Kitts/Nevis and Antigua, and Barbuda and trained 145 homebuilders (UNDP 2004). In the Antigua-Barbuda Pilot Project, 100 homeowners and three of the country's major insurers participated. In the Hurricane Resistant Home Improvement program, a U.S. non-governmental organization built capacity of local builders to offer disaster-resilient homes using home improvement loans from local banks. In St. Lucia, a group insurance policy was obtained for participants. Possibilities for leveraging efforts to date include incorporating village-scale measures with joint adaptation/mitigation qualities.

receptivity to arrangements like these, noting the new imperatives presented by climate change (Munich Re 2004; UNEP and Innovest 2002).

CDMP was, however, a very rare example of cooperation between the international relief community and insurers. The "cultures" of these two communities are extraordinarily different—values, priorities, timeframes, economic perspectives—and no concerted efforts have been made to build the necessary bridges. As an illustration of how these and others map to public-sector objectives, Table 3 relates the principles below to priorities stated by the U.S. Agency for International Development.

9 The way forward

The view that climate change is a strategic business risk is more prevalent in the insurance industry than any other segment of the financial services sector (UNEP and Innovest 2002).



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Table 3

High- efficiency, grid- independent lighting systems	
Mitigating High- urban heat efficie islands grid- indep lightii syster	
Energy- efficient water disinfection	
Energy- efficient, disaster- resilient buildings & farms	
Sustainable Energy- agriculture efficient disaster- resilient building	•
Sustainable forest management	
Risk mapping	•
Innovative insurance products (e.g. Microinsurance, energy savings insurance, weather derivatives)	•
Training & capacity building on insurance & risk management	ral resources
	Improved protection and sustainable use of natural resources Providing biodiversity conservation through on- the-ground conservation initiatives and dissemination of best management practices Improving the design and implementation of policies that affect biodiversity use and conservation Providing technical assistance to field missions in • strategic planning, program design, and monitoring of biodiversity programs Reducing damage to forests by inappropriate wood harvesting techniques Promoting rehabilitation of degraded land Increasing local participation in forest and tree system management Establishing integrated monitoring and assessment of forest resources to conserve biodiversity and improve forest health. Strengthening the individual and institutional capacity of non-governmental organizations (NGOs), community-based organizations and coastal resources management



Table 3 continued

	Training & capacity building on insurance & risk management	Innovative insurance products (e.g. Microinsurance, energy savings insurance, weather derivatives)	Risk mapping	Sustainable forest management	Sustainable Energy- agriculture efficient disaster- resilient building	Energy- efficient, disaster- resilient buildings & farms	Energy- efficient water disinfection	Mitigating urban heat islands	High- efficiency, grid- independent lighting systems
Promoting new initiatives that help communities identify, value, and better manage freshwater and coastal resources under their control									
Increasing public awareness of and participation in freshwater and coastal resources management	•								
Improving the design and implementation of policies that affect water use	•								
Create low-cost/low-maintenance water treatment and disinfection systems							•		
Improved management of urbanization in target areas	ıreas								
Improving living conditions and minimizing disaster risks, especially for urban slum settlements						•		•	•
Increasing equitable delivery of water, electricity, and waste disposal services							•		
Expanding the private sector's role in partnering with cities to provide services and shelter for the poor		•						•	
Incorporating people and community needs into urban management			•			•		•	
Increased Environmentally Sustainable Energy Production and Use	oduction and U	Jse							



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	Training & capacity building on insurance & risk management	Innovative insurance products (e.g. Microinsurance, energy savings insurance, weather derivatives)	Risk Sustai mapping forest manag	Sustainable forest management	Sustainable agriculture	Energy- efficient, disaster- resilient buildings & farms	Energy- efficient water disinfection	Mitigating urban heat islands	High- efficiency, grid- independent lighting systems
Promoting energy efficiency and environmental management systems in cities, transport and industry						•		•	•
Expanding electrification activities to rural and economically disadvantaged urban areas							•		•
Fostering implementation of policy and regulatory changes that clarify or establish rights and incentives for the cost-effective utilization of renewable energy resources and technologies		•				•	•		•
Developing productive use of energy in applications such as irrigation pumping, drip irrigation and processing agricultural commodities, communications, and information technologies						•			
Improving public and private sector institutional ability to administer the energy sector, allow for more effective delivery of energy services to rural and urban populations, and expand improved urban environmental management systems		•				•	•	•	•
Reduced threat to sustainable development from global climate change	global climate	change							



Table 3 continued

	capacity insurance building on products (e insurance & Microinsurrisk energy sav management insurance, weather derivatives	capacity insurance building on products (e.g. insurance & Microinsurance, energy savings management insurance, weather derivatives)	mapping forest	forest agriculture efficient, management resilient resilient buildings & farms	agriculture	efficient, disaster-resilient buildings & farms	efficient water disinfection	urban heat efficientials and a grid-indeperture indeperture indeperture system	efficiency, grid- independent lighting systems
Advancing approaches that promote climate- friendly technologies and carbon sequestration through innovative energy, forestry, and agricultural practices									
Developing projects that reduce greenhouse gas emissions through cost-effective interventions				•	•	•	•	•	•
Mitigating impacts on food production, human health, the natural resource base and coastal areas caused by climate change, land use change, and long-term changes in precipitation patterns	•	•	•	•	•	•	•	•	•

* Energy/Environment Objectives from: USAID, 2002. "Public Private Alliances in Agriculture, Anti-Corruption/Governance/Civil Society Strengthening, Conflict/Relief and Humanitarian Assistance, Economic Growth and Trade Capacity Building, Education, Environment/Energy, Health, Information Technology." Annual Program Statement, APS No. GDA-03-001, U.S. Agency for International Development http://www.usaid.gov/gda/aps2003.doc



However, according to a group of 90 concerned insurance companies working under the auspices of the United Nations Environment Programme (UNEP), insurers and reinsurers have not yet broadly responded to calls to help emerging markets prepare for and respond to climate change. The UNEP insurers' group argues that proactive steps would be in the industry's financial interest and be consistent with the industry's underlying philosophy of risk management.

It is widely recognized that the lack of information is one of the central barriers to improved adaptive capacity to natural disasters (Smit et al. 2001). Beyond the growing number of exemplary industry leaders, many members of the insurance industry have thought little, if at all, about the nexus between extreme weather events, and climate change; these participant in the industry could benefit from focused communications efforts (UNEP and Innovest 2002).

Increased collaboration between the insurance and climate-modeling communities could significantly improve the quality of data and risk analysis, facilitating increased availability of insurance in regions where a current lack of information is an obstacle to market development. With such information in hand, the insurance industry could increase its efficacy as a channel of information on disaster preparedness and recovery for their customers. The importance of improved data and modeling is central, as evidenced by a shift in the industry (thanks in part to better models) towards accepting flood risks where they previously had been viewed as uninsurable (Swiss Re 2003c). The largest U.S.-based catastrophe modeler (RMS) has recently begun to incorporate the effects of climate change in its forward-looking projections.

Involving the insurers of extreme weather events in the development and execution of strategies that contribute to public health and sustainable development would enhance disaster resilience, reduce the magnitude of losses, and thus help increase insurers' willingness to establish, maintain, and expand a constructive presence in emerging markets. We offer the following principles for establishing priorities and creating effective projects in insurance and sustainable development:

- Raise awareness within the insurance sector.
- Focus on efforts that enhance the fundamental insurability of weather-related risks.
- Couple insurance efforts with core development activities.
- Foster efficient domestic government and private insurance risk sharing.
- Build domestic/local insurance and risk-management capacity.
- Discourage complacency in response to insurance availability or government aid.
- Respond to insurers' other priorities, e.g. corporate governance, construction liability (vis a vis moisture risks).
- Address life and health insurance issues along with those related to property damage.
- Harness market-pull forces (e.g., foster aggregated demand for insurance products).
- Understand insurers' relationship to the security implications of climate change, e.g. via political risks and business interruptions.
- Utilize public-private partnerships in carrying out the aforementioned activities.

A constructive starting point for enhancing market opportunities for insurance of natural disasters is to address ways in which current or anticipated risks are perceived as uninsurable. Table 4 scopes the complex definition of insurability and illustrates specific strategies to address such concerns, including activities such as improving the modeling and data on disaster exposures and potential costs, establishing and enforcing improved building codes, establishing solvency regulation for insurers to obtain an appropriate



zone mapping) and climate/impact modeling for

Table 4 "Insurability" as it pertains to climate change

Conditions contributing to insurability	Means of achieving insurability
Assessable Risk: Insurers must understand the likelihood and estimated magnitude of future • Improved data (e.g., flood zone mapping) and climate/im claims and be able to unambiguously measure the loss. This is essential for pricing, especially where regulators require that premiums be based strictly on historic experience (rather than projections). For example, some insurers and reinsurers currently avoid Asia and South America but have expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expanding into these regions if loss and expressed interest in expression expressed interest in expression	 Improved data (e.g., flood zone mapping) and climate/im developing countries and economies in transition.
Randonness: If the timing, magnitude, or location of natural disasters were known precisely, • Statistical and monitoring systems. the need for insurance would be reduced and the willingness of insurers to assume the risk Accountability and legal remedies for insurance fraud. would vanish. Intentional losses are not insurable. If losses can be predicted, only those who were going to make claims would purchase insurance, and insurance systems would not function.	Statistical and monitoring systems. Accountability and legal remedies for insurance fraud.
Mutuality: The insured community must sufficiently share and diversify the risk. The degree Create sufficiently large and diversified pools of insureds of diversification for one insurer is reflected in the number of insurance contracts (or the "book of business" in insurance parlance), geographical spread, etc. The larger the pool, the greater the reduction of loss volatility. Such risks must also be uncorrelated so that large numbers of pool members do not face simultaneous losses.	Create sufficiently large and diversified pools of insureds.
Adverse Selection: Insurers need to understand the risk profile of the individuals in their market and be able to differentiate the exposures and vulnerabilities of the various	Gather market data on vulnerabilities and associated demog geographic distribution of risks.

erabilities and associated demographic and geographic distribution of risks.

customer subgroups. This can form the basis for differentiating premiums or coverage

geographical concentration of risks preceding the 9/11 disaster (Prince 2002) and the

constituencies creates elevated risk for insurers, thereby putting upward pressure on

offered. Lack of this information or use of insurance only by the highest-risk

pricing and affordability/availability. A key example is the lack of attention to the

Rely on government insurance or co-insurance (e.g., U.S. flood insurance Differentiate premiums among different (risk) classes of insureds. program)

ensuring that the insured "retains" a portion of the risk. Moreover, the insured must not Education and required risk reduction provided by a public or private entity. The use of deductibles is the standard method of Use of caps on claims paid Controllable Moral Hazard: The very presence of insurance can foster increased risk taking, which can be thought of as "mal-adaptation" to potential changes in weather-related events, which will, in turn, increase losses. This is an issue whether the insurance is ensuing public debate on the insurability of terrorism risks. intentionally cause losses.

Use of proportional deductibles (insured pays a percentage of all losses) Use of fixed deductibles (insured pays a fixed amount of any loss)

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Conditions contributing to insurability	Means of achieving insurability
Managable Risks: The pool of potentially insurable properties, localities, etc. can be expanded if there are technical or procedural ways to physically manage risk.	Building codes and enforcement Early warning systems Disaster preparedness/recovery systems
Affordability: "Affordability" implies that a market will be made, i.e., that the premiums required will attract buyers. If natural disaster losses or other weather-related losses are too great and/or too uncertain, an upward pressure is placed on prices. The greatest challenge is insuring poor households and rural businesses. This is evidenced by the ~ 50 percent increase in life insurance premiums in Africa in response to the AIDs epidemic (Chordas 2004).	Micro-insurance or other schemes to facilitate small insurance for small coverages. Systems must maintain solvency following catastrophic events. Government subsidy of insurance costs; provision of backstop reinsurance
Solvency: For an insurance market to be sustainable (and credible), insurance providers must solvency regulation (e.g., to ensure sufficient capital reserves and conservatism remain solvent following severe loss events. Natural disasters have caused insolvencies in how they are invested) (Swiss Re 2001) (bankruptcies) among insurers in industrialized countries (Mills et al. 2001), and insurers Risk pooling; Government insurance in emerging markets are even more vulnerable. Solvency has been eroding for other rating systems	Solvency regulation (e.g., to ensure sufficient capital reserves and conservatism in how they are invested) (Swiss Re 2001) Risk pooling; Government insurance Insurer rating systems
Enforceability: Trust and contractual commitments underpin the successful functioning of Contract law insurance markets. Insureds must be confident that claims will be paid, and insurers must Customer addreceive premium payments. Recent large-scale fraud in the weather derivatives market underscores this issue (McLeod 2003). Many transitional economies, e.g., China, still Regulatory or have sufficiently unformed legal systems (Atkinson 2004).	Contract law Customer advocates Regulatory oversight of insurance operations, pricing, claims processing



balance between operating profitability and reserving for major losses, and providing for early warning systems and disaster-recovery assistance. An example of a government initiative to enhance insurability is Puerto Rico's Reserve for Catastrophe Losses, under which a portion of which property insurance premiums is passed to a trust. According to Auffret (2003), "it is anticipated that this mechanism will improve the availability and affordability of catastrophe reinsurance and reduce the dependency of Puerto Rican insurers on foreign reinsurance."

The success or failure of insurance also depends on the political, fiscal, and regulatory environment (Mills et al. 2002). ¹⁴ Examples of regulatory interventions include restrictions on pricing, the types of investments insurers can make, limitations placed by host countries on access to international markets, disclosure requirements, and allowable reserve accumulations (Auffret 2003). Effective insurance regulation must strike a balance between allowing insurers an attractive return on their business activities while ensuring their solvency (and ability to pay claims) in the event of major losses and maintaining the affordability and availability of insurance for the public. Other needs include regulatory policies that support fiscal transparency and responsibility, and measures that can garner the trust of the insurance-buying public. Notably, the U.S. National Association of Insurance Commissioners (NAIC) took up these issues for discussion in 2005.

As insurers have many "fires to fight," and environmental issues such as natural or human-induced climate change must compete for attention with other critical issues, key target markets (economic, demographic, and geographic) should be identified, and proposed initiatives should clearly define their relevance to the insurers. Collaborations should include insurance brokers and other important trade allies. It is incumbent on public entities seeking partnerships with insurers to exercise patience, while establishing and demonstrating the value of these partnerships.

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¹⁴ For example, the introduction of tax-deductible life insurance premiums boosted the premium growth rate in Mexico and in Brazil (Swiss Re 2003a). In contrast, financial crises can dampen insurance markets in various ways.



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